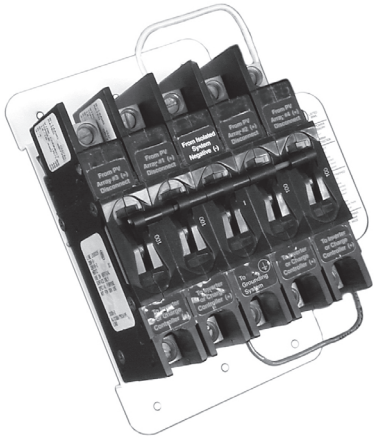
PVGFP

Photovoltaic Ground Fault Protection



Installation and Operation Guide

P/N 971-0001-01-01 Rev. A 10/99

PVGFP
Photovoltaic Ground Fault Protection

Table of Contents

IMPORTANT SAFETY INSTRUCTIONS

This manual contains important safety instructions that should be followed during the installation and maintenance of this product.

To reduce the risk of electrical shock, and to ensure the safe installation and operation of this product, the following safety symbols have been placed throughout this manual to indicate dangerous conditions and important safety instructions.

WARNING - A dangerous voltage or condition exists in this area. Use extreme caution when performing these tasks.

CAUTION - This procedure is critical to the safe installation or operation of the unit. Follow these instructions closely.

NOTE - This statement is important. Follow instructions closely.

- All electrical work must be done in accordance with local, national, and/or international electrical codes.
- Before installing or using this device, read all instructions and cautionary markings located in (or on) the manual, the controller, the batteries, and the PV array.
- Do not expose this unit to rain, snow or liquids of any type. This product is designed only for indoor mounting.
- To reduce the chance of short-circuits when installing or working with the inverter, the batteries, or the PV array, use insulated tools.
- Remove all jewelry such as rings, bracelets, necklaces, etc., while installing this system. This will greatly reduce the chance of accidental exposure to live circuits.
- The inverter contains more than one live circuit (batteries and PV array). Power may be present at more than one source.
- This product contains no user-serviceable parts. Do not attempt to repair this unit.

SAVE THESE INSTRUCTIONS

1.0 INTRODUCTION

The PVGFP (PV Ground Fault Protection) is designed to minimize the possibility of a fire resulting from ground faults in a PV array (in accordance with Article 690-5 of the National Electric Code (NEC) for rooftop-mounted photovoltaic (PV) systems on dwellings). It is not designed or intended to prevent electrical shock or to be used for PV dc over current. Whenever the PVGFP detects a ground fault current (in excess of one ampere), it interrupts the fault current, disconnects the PV array from the rest of the system, and indicates that a fault has occurred.

Features

- The PVGFP is UL listed to Draft Standard 1741 as a Photovoltaic Power System Accessory for Photovoltaic Array Ground Fault Protection.
- Can be configured for use with 12, 24, or 48 volt dc nominal systems with a maximum PV sub-array open circuit rating of 125 volts dc.
- Available in four capacities to match individual system requirements; 100, 200, 300 and 400 amps dc (100 amps maximum/circuit).
- Lowest cost UL-approved photovoltaic ground fault protection system for residential installations on the market today.

The PVGFP comes configured to match the number of sub-arrays in the system (the quantity of sub-arrays is equal to the number value in the model designation). For example, PVGFP2 is required for two sub-arrays in a stand-alone system. PMK-PVGFP3 is required for three sub-arrays in a Trace Power Module system.

1.0 INTRODUCTION

Model Types

The following PVGFP models are available from Trace Engineering as either a factory installed option or a field retrofit option. All field retrofit options must be installed by qualified personnel.

The PVGFP1 (through 4) can be installed in an electrical enclosure supplied by the user. Minor system modifications and additional hardware may be required.

The UTO- series (PVGFP1 through 2) is factory installed (as an option) in the SWODE/Utility systems. This option must be ordered with the utility system.

The UTK- series (PVGFP1 through 2) is designed to be field installed in existing SWODE/Utility systems. Minor modifications are required.

The PMO- series (PVGFP1 through 4) is factory installed (as an option) in all Trace Power Module systems. This option must be ordered with the utility system.

The PMK- series (PVGFP1 through 4) is designed to be field installed in existing Power Module systems. Minor modifications are required.

NOTE: The ground fault protection units can not be expanded for additional PV sub-arrays. Ensure the PV ground fault unit contains the proper number of protection switches (1 through 4) for the PV sub-arrays requiring protection (or future expansion) before installing in a system.

CAUTION: The PVGFP does NOT replace the need for branch circuit protection. Each PV sub-array still requires a fuse or circuit breaker disconnect to protect against over current and short circuits.

NOTE: Additional hardware may be required to complete some steps described in this manual. Please read all applicable procedures and obtain any additional hardware before attempting to install the PVGFP.

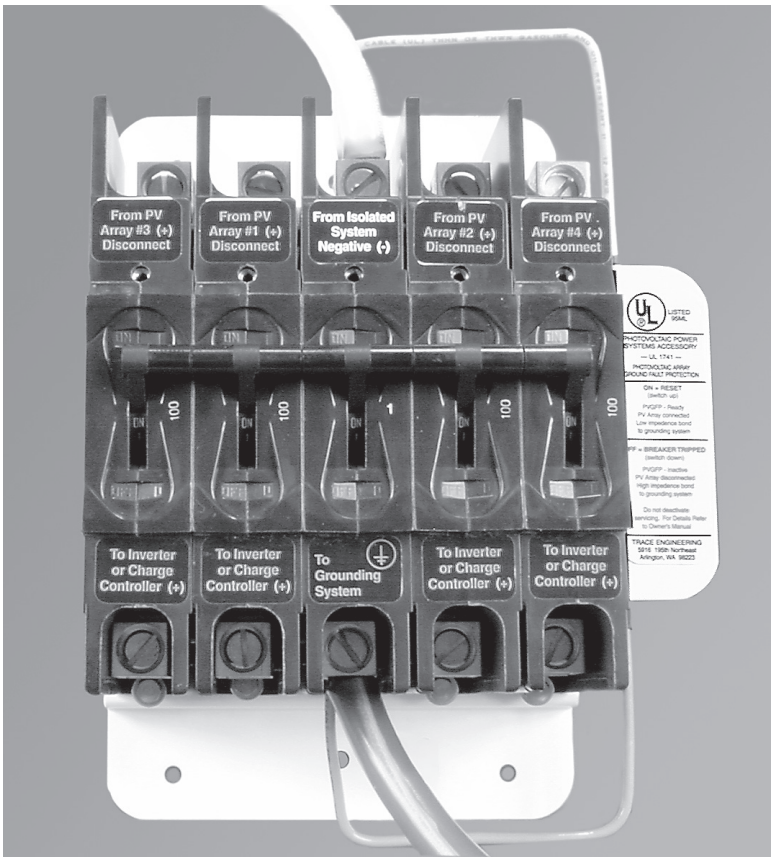


Figure 1
PVGFP4 (Four PV Ground Fault Disconnect Switches)

2.0 INSTALLATION

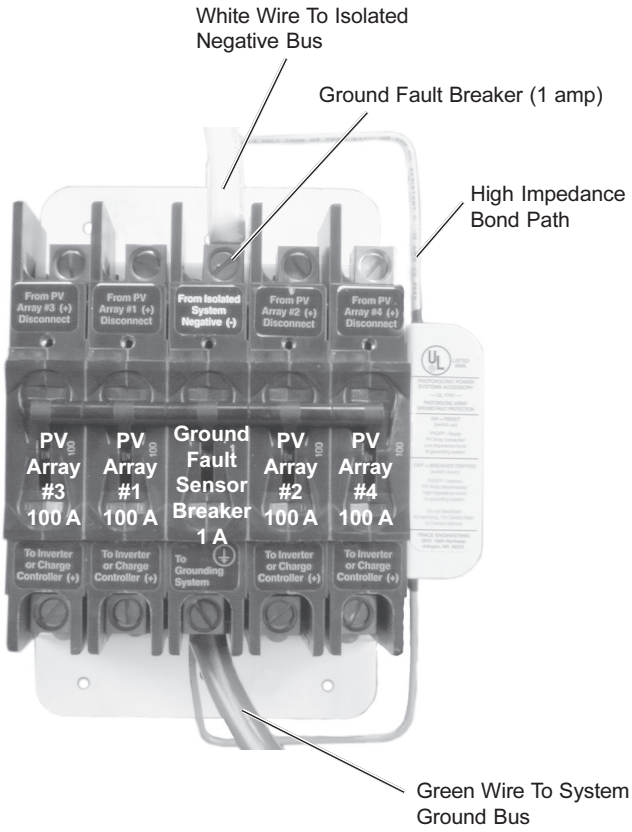


Figure 2
PVGFP Front View

NOTE: Before installing the PVGFP, read all instructions and cautionary markings located in this manual.

NOTE: The PVGFP must be mounted in a vertical position for proper operation.

2.0 INSTALLATION

Mounting:

1. If the PVGFP is installed outdoors, it must be mounted inside a weather-tight enclosure which is suitable for outdoor applications. If the PVGFP must be installed in close proximity to the batteries, make sure the area is adequately ventilated to the outside.

2. Mount the PVGFP vertically with the circuit breaker in the ON position.

3. Depending upon the type of system (custom, Power Panel, Power Module, or Utility-tie), the installation procedure varies. Refer to the appropriate procedure in this manual.

Tools required:

#2 Phillips screw driver	Level
1/4" Slotted screw driver	Wire strippers
Allen wrench	Torque wrench
Multimeter	Pencil

Hardware / Materials required:

Screws (applicable for application)	Conduit and appropriate fittings
Wire nuts	Electrical Tape

Optional Hardware (see text)
Shunt (with tapped holes for bus-bar), Trace Engineering p/n 2377-1
Bus-bar (attaches to shunt)

Wiring

1. All wiring and installation methods must conform to applicable electrical and building codes.

2. The PVGFP breakers accept wire sizes up to #1/0 AWG. Always use the same gauge wire between the PV array and the dc circuit breakers. For maximum safety, run dc cables in conduit.

NOTE: U.L. has not certified the breaker assembly for #1/0 AWG wire.

3. The PVGFP must be installed in addition to any PV array main disconnects. The disconnects on the PVGFP are switches that open only when a PV array ground fault (of at least one amp) is sensed or when the PVGFP is manually deactivated.

4. Locate the PVGFP as close as practical (where it can be easily seen and reset) to the dc conductors coming from the PV array and the dc negative/ground system-bonding point. Roof mounting is not recommended.

CAUTION: The factory-installed large (#2 AWG) and small (#12 AWG) conductors connected to the PVGFP circuit breaker must never be loosened or reconnected. They have been factory installed and torqued to UL standards. Periodic tightening of all wire connections as part of a regular maintenance schedule is recommended.

NOTE: Never connect two wires into one pressure terminal.

2.0 INSTALLATION

Wiring, *(continued)*

5. All dc negative wires (PV, battery, inverter, etc.) must be connected to an isolated grounding bus-bar or bonding block (insulated from the chassis enclosure).

6. All equipment grounding wires from the PV module frame, enclosures, and grounding rod wire, must be connected to a separate grounding bus. This bus may be connected directly to the metal enclosure. Additional parts may be required (i.e., grounding block).

7. Torque wire connection screws according to Table 1.

WARNING: USE INSULATED TOOLS WHEN TORQUING THE CONNECTION SCREWS.

Wire Size	Torque
14–10 AWG	35 in. lbs
8 AWG	40 in. lbs
6–4 AWG	45 in. lbs
3–1 AWG	65 in. lbs

Table 1
Wire Connection Torque Requirements

NOTE: In non-PVGFP installations, the dc negative wires are connected to the same grounding block used for equipment grounding via the ground rod. PVGFP installations require that this bond be separated into two individual paths as the ground/negative bond is established by the PVGFP. Ensure that all negative wires connect to the negative block and all grounding wires connect to the grounding block.

NOTE: The PVGFP wire terminals accept wire sizes from 0-14 AWG CU/AL, rated at 60/75 °C.

NOTE: Torque specifications are provided up to wire size #1 AWG. U.L. has not certified the breaker assembly for #1/0 AWG wire.

Installation in Non-Trace Enclosures

1. Ensure the enclosure is large enough to house the PVGFP and allow for proper wire clearances around the assembly to meet code requirements.
2. Install the PVGFP in an approved electrical enclosure.
3. Refer to Figure 3 for minimum enclosure dimensions.

NOTE: Refer to Figure 8 for a basic wiring diagram.

NOTE: The PVGFP mounting plate is the same size for all models.

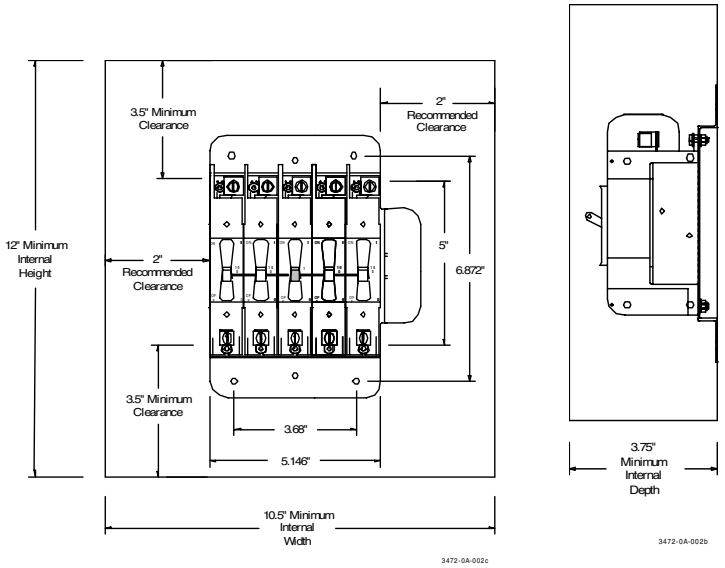


Figure 3
PVGFP-x Installation Dimensions for Non-Trace Enclosures

Installation in a PMK Trace Enclosures

The PMK series of PVGFPs are designed to be mounted in Trace Power Module systems. The mounting procedures are identical for all four model PVGFPs.

Removal of Ground/Neutral Bonding

Before mounting the PVGFP check the existing DCBB, shunt assembly to see if it is the standard version or the GFPBB version. The standard version bonds the shunt and ground bus via five bonding bars. The DCBB shunt assembly needs to be modified to separate the dc negative/ground bond as this will now be done by the PVGFP.

The DCBB shunt assembly can easily be modified for the PVGFP by following the procedure below.

NOTE: A replacement shunt (p/n 2377-1) and additional bus-bar (p/n 3170-1) can be ordered from Trace Engineering. This shunt contains threaded screw holes to connect the additional side bus-bar. Ensure you have these available before proceeding.

Procedure

1. If the shunt in the Power Module enclosure looks like the illustration in Figure 4, it is the standard DCBB bonded shunt assembly.

2. Use a 9/16" socket and remove the hex screws holding the bond bars to the shunt and ground blocks. The dc negative (shunt) and ground bus are now separated.

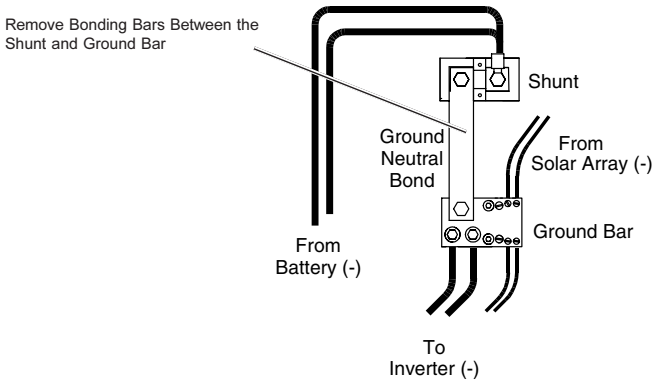


Figure 4
Standard DCBB Bonded Shunt Assembly

Removal of Ground/Neutral Bonding, *(continued)*

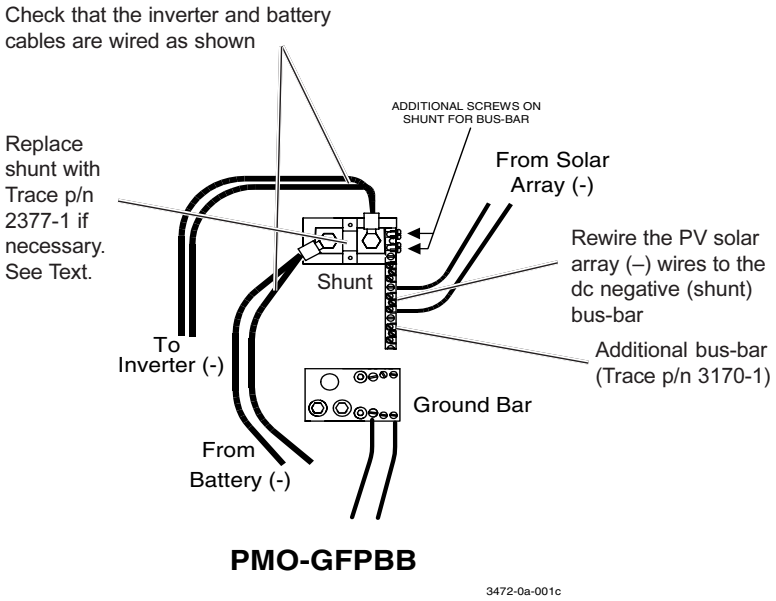


Figure 5
GFPBB Wiring

3. Check the existing wiring and make sure the inverter cables connect to the right-hand terminal on the shunt and the battery cables connect to the left-hand terminal. If these cables are reversed, change them as just described and shown in Figure 5.

4. If the shunt does not contain threaded screw holes for the side bus bar, it is recommended to order part number 2377-1 (shunt) and p/n 3170-1 (bus-bar) from Trace Engineering, and replace the existing shunt. This shunt contains the proper threaded screw-holes to connect the side bus bar.

5. Remove the PV array negative wires from the ground block and relocate them to the dc negative (shunt) bus bar as shown in Figure 5.

PMK-PVGFP Mounting

1. Mount the PVGFP unit to the left of the dc negative shunt, and next to the right-hand C40 controller. Use four 10-32 x 1/2" screws, star washers and 10-32 nuts (supplied) to attach the PVGFP unit to the Enclosure. Refer to Figure 6 for mounting location.

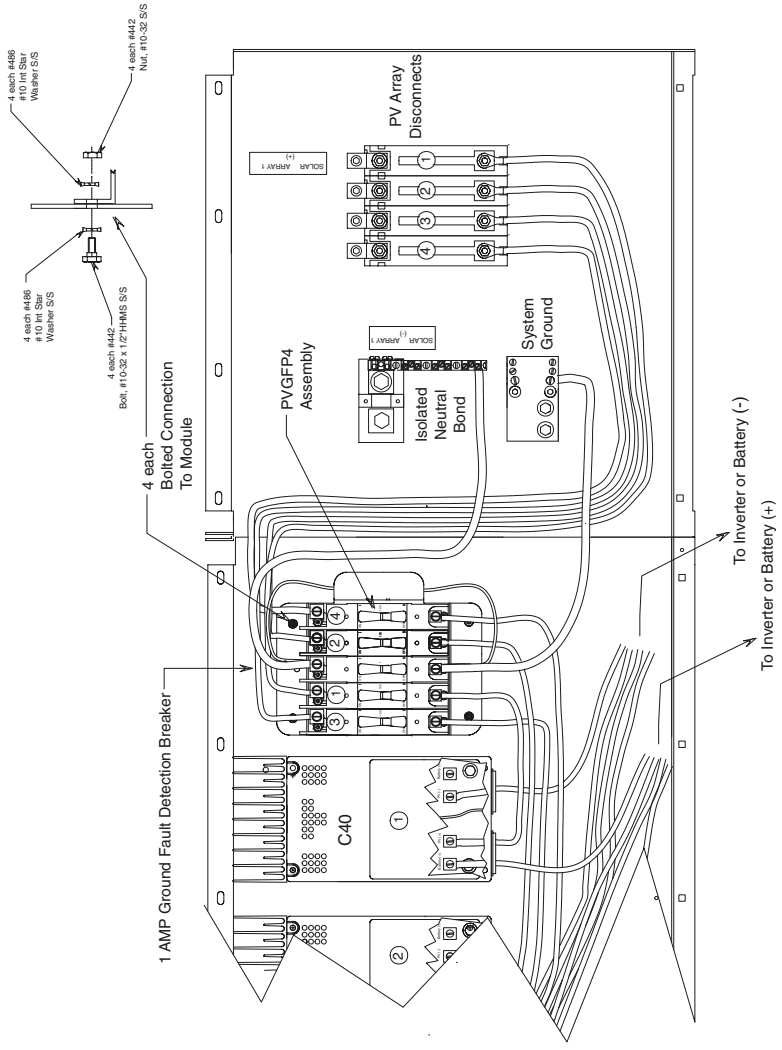


Figure 6
PMK-PVGFP Installation

PMK-PVGFP Wiring

1. Connect the white wire from the PVGFP to the isolated neutral bus.
2. Connect the green wire from the PVGFP to the Ground Block.
3. Tighten the connections. Refer to Figure 7.
4. Connect a #6 AWG red wire from the lower terminals on the PV array disconnect breakers to the upper terminals on the PVGFP as shown in Figure 6.
5. The lower terminals from the PVGFP are routed to the charge controller's PV + Terminals. Refer to the schematic diagram (Figure 8) for system wiring.
6. Refer to the inverter/charger's and Controller Installation/Operator's manual for additional wiring details.

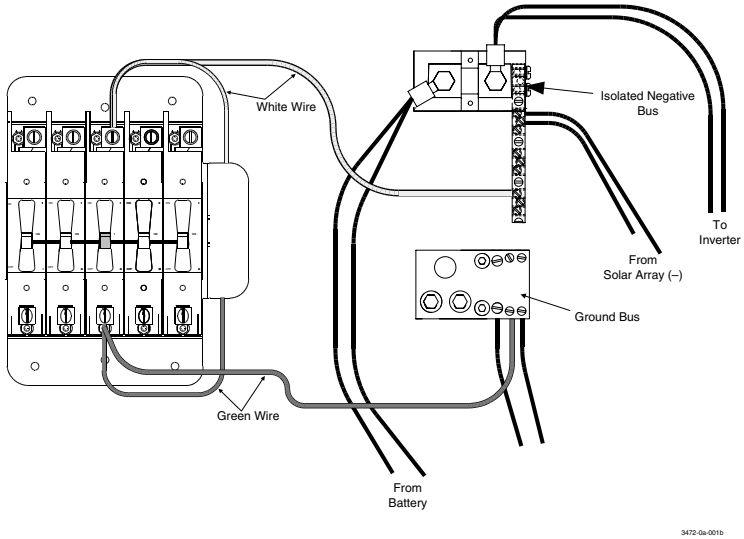


Figure 7
PVGFP Wiring

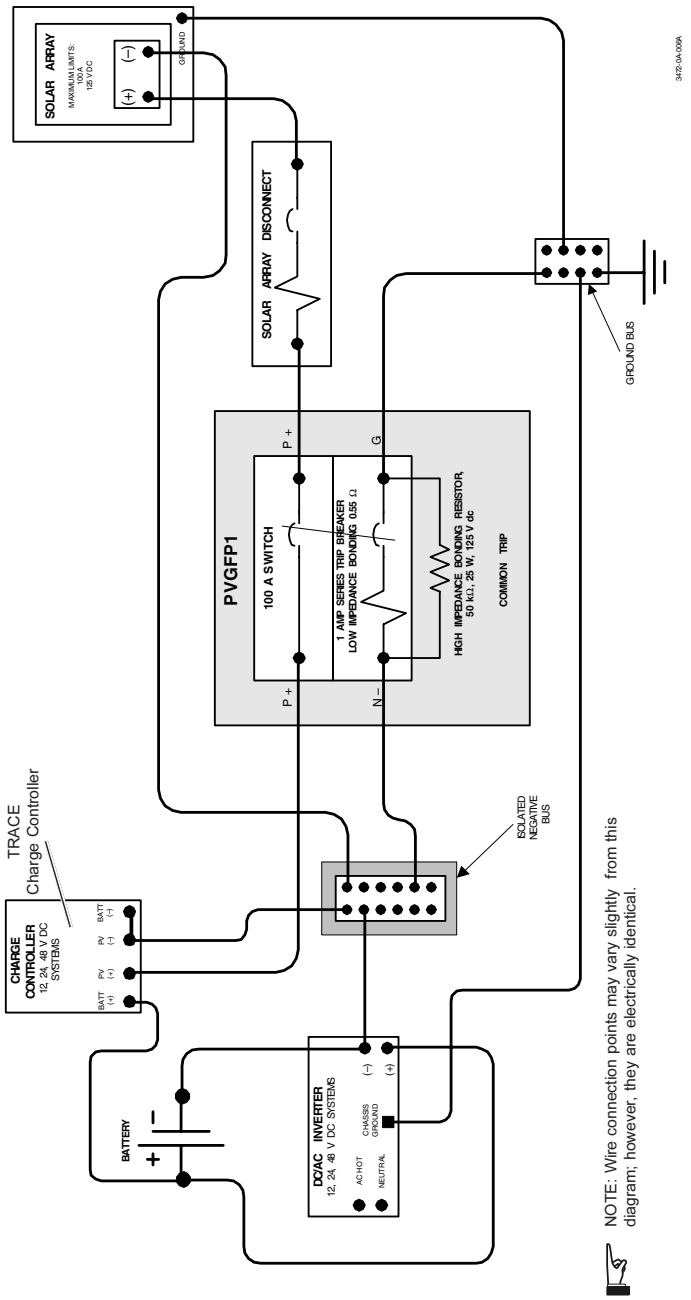


Figure 8
Basic Wiring Diagram

UTK-SWODE Enclosure Installation

The PVGFP can be used to replace the old style GFP or to retrofit an existing utility line-tie unit mounted in a SWODE utility line-tie enclosure. Minor modifications must be performed to the assembly in order for the PVGFP to operate properly.

1. Connect the white wire from the PVGFP's 1 amp ground fault sensor breaker to the inverter's negative terminal.

2. Connect the PV sub-array positive wires to the solar array disconnect breaker(s) on the side wall of the enclosure.

3. Connect each positive wire from the solar array disconnect breaker(s) to one of the top terminals of the PVGFP. One circuit per pole as labeled.

4. Connect the positive wire from the lower terminals of the of each PVGFP to the inverter's positive terminal.
5. Connect the PV sub-array negative wires to the inverter negative terminal using crimped ring terminals.

6. Remove the factory installed ground bond connected between the inverter's negative (–) terminal and the chassis ground lug. The only neutral ground bond on the dc circuit should be through the PVGFP.

7. Connect the green wire from the PVGFP's 1 amp ground fault sensor breaker to the ground lug on the inverter's chassis.

8. Refer to Figure 8 for the basic wiring diagram and Figure 9 for a diagram of the SWODE enclosure.

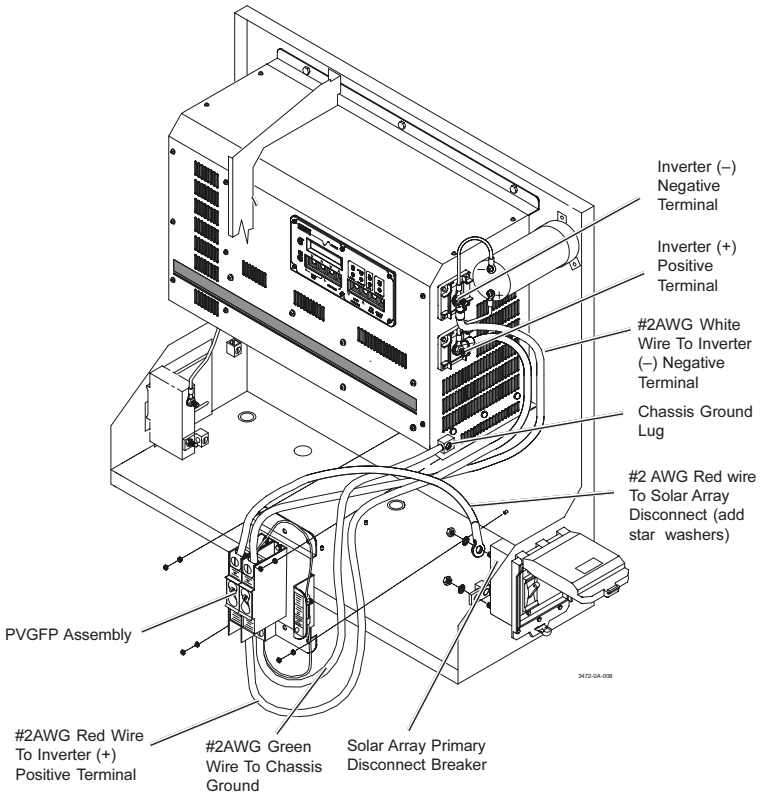


Figure 9
PVGFP1 Installation in a UTK SWODE Enclosure

Testing the PVGFP Installation

Once the PVGFP is installed, all wiring should be checked. Ensure that there are no neutral/ground bonds (or dc negative/ground bonds in dc only systems). Check that each positive wire from the primary PV 100 amp disconnect breaker is properly routed to the PVGFP switches and that all contacts are tight.

Before placing the system into operation, it should be checked to ensure the PVGFP is operating properly. The first test will check the bond resistance as well as the high impedance resistance. The second test checks the 1 amp trip current of the PVGFP.

Tools Required:

DC Multimeter (0-1 amp min, 0-1 MΩ)
DC Power Supply (optional), (0-48 V dc, 1 amp min.)

Resistance Check

Check the continuity of the high impedance bond. All power sources must be disconnected for this test.

a. Connect the ohmmeter between the ground block and negative/neutral block in the enclosure. Set the meter to its lowest resistance range. Refer to Figure 10 for location of the neutral and ground blocks.

NOTE: Connect the ohmmeter between the inverter's negative terminal and chassis ground lug for SWODE installations. Refer to Figure 9 for locations.

b. Close the PVGFP switch (ON position) and measure the resistance. It should measure between 0 to 2 ohms.
c. Set the meter to read a resistance of 50 kΩ. Open the PVGFP switch (OFF position) and measure the resistance. It should now read between 50-60 kΩ. This is the high impedance bond resistance.

Disconnect and remove the ohmmeter.

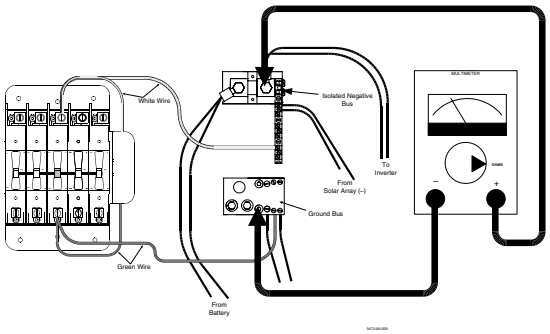


Figure 10
Resistance Check Setup

1 Amp Trip Current Test

This test uses a dc power supply set at the system voltage (i.e., 12, 24 or 48 V dc) and a dc ammeter to supply a 1 amp current to trip the breaker. If the test power supply contains an accurate internal ammeter, the external ammeter is not required.

A. DC Trip Test Using a Power Supply

a. Disconnect all sources of power.
b. Set the power supply to the proper system voltage (12, 24, or 48 V dc).
c. If the power supply does not have a meter to display current, insert an ammeter in series with the power supply. Refer to Figure 11.
d. Connect the power supply between the negative (top) terminal and ground (lower) terminal of the 1 amp PVGFP breaker.
e. Apply 1-2 amps of current from the power supply to the PVGFP. The PVGFP breaker should trip and open all PV disconnect switches.

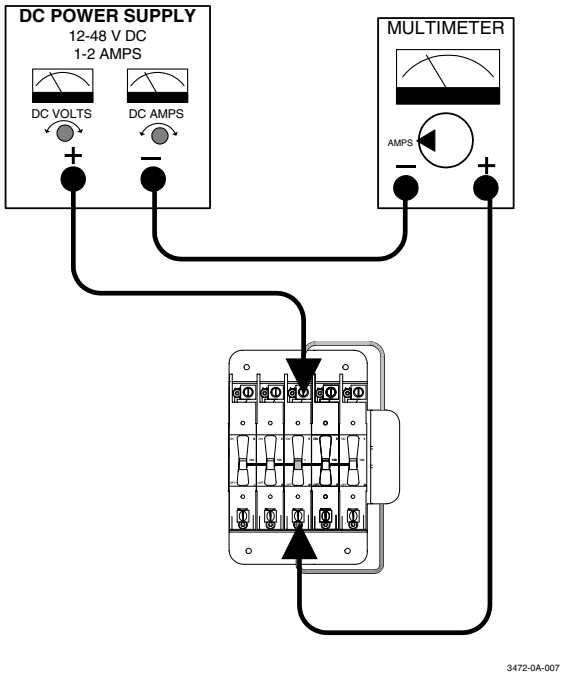


Figure 11
PVGFP 1 Amp Current Trip Test Using a Power Supply

B. DC Trip Test Using a Shorting Wire

If a power supply is not available to test the PVGFP, the PV array current may be used to simulate a short circuit. This test must be performed in daylight.

WARNING: THIS METHOD USES LIVE DC VOLTAGES AND HIGH CURRENTS. PROCEED WITH CAUTION. WHEN PERFORMING THIS TEST, THE BREAKERS SHOULD TRIP CAUSING A LOUD SOUND, THE WIRE MAY ALSO CAUSE A MOMENTARY ARC. BE PREPARED!

A. Short Circuit Test

a. Switch OFF all sources of power.
b. Switch ON the primary disconnect for PV array #1.
c. Switch the PVGFP to the ON position.
d. Use a heavy gauge "U" shaped wire, and momentarily connect it between the PV array #1 terminal and negative terminal of the 1 amp PVGFP breaker. Refer to Figure 12.
e. The PVGFP breaker should trip and open all the PV disconnect switches on the PVGFP.

NOTE: The primary PV array disconnect breaker may trip also. This is normal.

Failure to pass any of these tests indicates a faulty PVGFP unit.

Reinstall the covers on the enclosure if all system wiring is completed. Refer to the system manual for instructions.

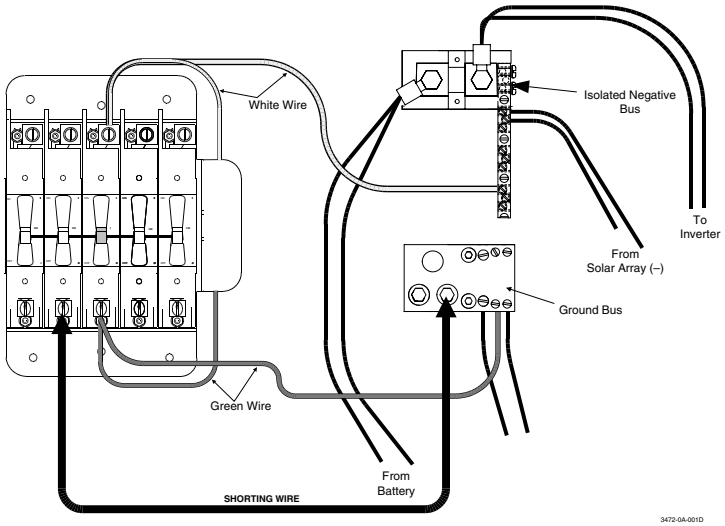


Figure 12
Current Trip Test Using a Shorting Wire

Operation

Once the entire system is wired (refer to the system manuals), and the PVGFP is tested. Place the PVGFP switch in the ON (upper) position. If the PVGFP breaker should trip any time during operation, troubleshoot and correct the cause of the ground fault current before resetting the breakers.

Maintenance

Annual inspection should include tightening all connections and field testing of the PVGFP. Refer to page 6 for tightening torques.

WARNING: USE INSULATED TOOLS WHEN TORQUING THE CONNECTION SCREWS.

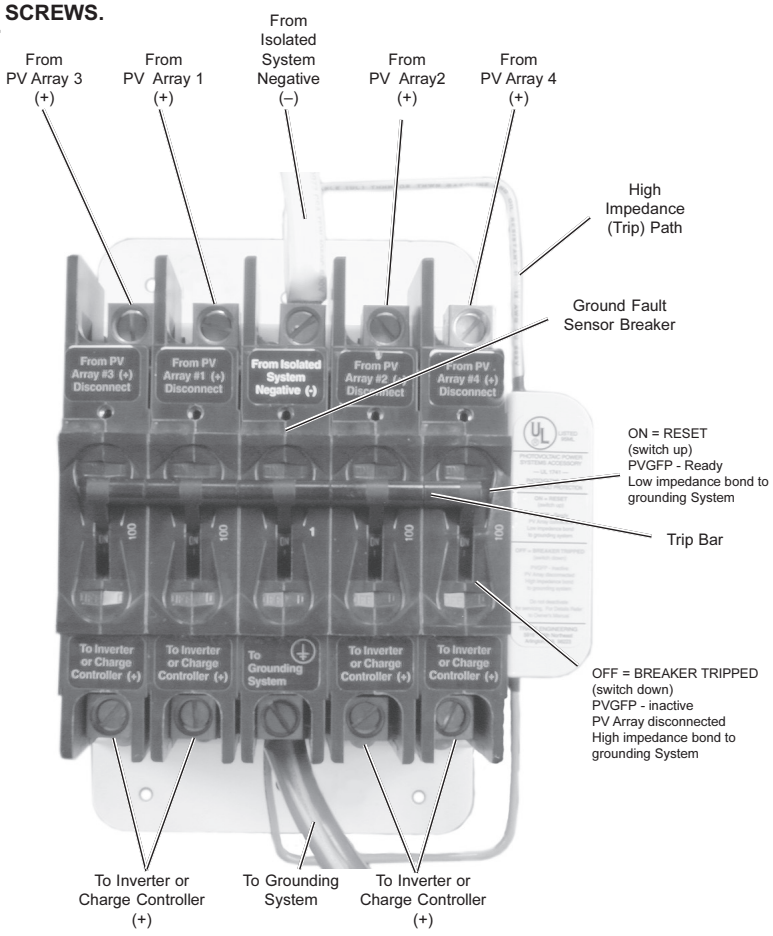


Figure 13
Connections and Trip Bar

Part Number	Maximum Number of Sub-Arrays	Maximum PV Open Circuit Rating (dc V)	Maximum PV Array Current Rating	Nominal System Voltage Rating	Weight lbs (kg)	Dimensions W x H x D
PVGFP1 **UTK-PVGFP1** **PMK-PVGFP1**	1	125 V dc	100 amps	12, 24, 48 V dc	3.5 lbs (1.59 kg)	6.5" x 8" x 3.75" (16.5 x 20.3 x 9.5 cm)
PVGFP2 **UTK-PVGFP2** **PMK-PVGFP2**	2	125 V dc	200 amps (100 amps x 2 sub-arrays)	12, 24, 48 V dc	4.5 (2.04 kg)	6.5" x 8" x 3.75" (16.5 x 20.3 x 9.5 cm)
PVGFP3 **PMK-PVGFP3**	3	125 V dc	300 amps (100 amps x 3 sub-arrays)	12, 24, 48 V dc	5.5 (2.5 kg)	6.5" x 8" x 3.75" (16.5 x 20.3 x 9.5 cm)
PVGFP4 **PMK-PVGFP4**	4	125 V dc	400 amps (100 amps x 4 sub-arrays)	12, 24, 48 V dc	6.5 (2.94 kg)	6.5" x 8" x 3.75" (16.5 x 20.3 x 9.5 cm)

4.0 SERVICE INFORMATION

Trace Engineering takes great pride in its products and makes every effort to ensure your unit fully meets your independent powering needs.

If your product needs repair, contact our Service department at: (360) 435-8826 to obtain an RMA# and shipping information; or fax this page with the following information to: (360) 474-0616.

Please provide:

Model Number: _____
Serial Number: (if applicable) _____
Purchase Date: _____
Problem: _____

Include a telephone number where you can be reached during business hours and a complete return shipping address (P.O. Box numbers are not acceptable).

Name: _____
Address: _____
City: _____
State / Province: _____
Zip / Postal Code: _____
Phone: ( ) _____
Country: _____

Limited Warranty

Trace Engineering warrants its power products against defects in materials and workmanship for a period of two (2) years from the date of purchase and extends this warranty to all purchasers or owners of the product during the warranty period. Trace does not warrant its products from any and all defects:

(1) arising out of material or workmanship not provided by Trace Engineering;
(2) resulting from abnormal use of the product or use in violation of the instructions;
(3) in products repaired or serviced by other than Trace Engineering repair facilities;
(4) in components, parts, or products expressly warranted by another manufacturer.

Trace Engineering agrees to supply all parts and labor, or repair or replace defects covered by this warranty with parts or products of original or improved design, at its option, if the defective product is returned to any Trace Engineering authorized warranty repair facility or to the Trace Engineering factory in the original packaging, with all transportation costs and full insurance paid by the purchaser or owner.

All remedies and the measure of damages are limited to the above. Trace Engineering shall in no event be liable for consequential, incidental, contingent, or special damages, even if Trace Engineering has been advised of the possibility of such damages. Any and all other warranties, expressed or implied, arising by law, course of dealing, course of performance, usage of trade or otherwise, including, but not limited to, implied warranties of merchantability and fitness for a particular purpose, are limited in duration for a period of two (2) years from the original date of purchase.

Some countries or states do not allow limitations on the term of an implied warranty, or the exclusion or limitation of incidental or consequential damage, which means the limitations and exclusions of this warranty may not apply to you. Even though this warranty gives you specific legal rights, you may also have other rights which vary from state to state.

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NOTES

Use this page to record notes, phone numbers, part numbers, or setup information for future reference.

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